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ABSTRACT

The factors that influence the performance of undergraduate students in introductory biology courses were studied, considering cognitive, metacognitive, and behavioral factors. From 612 participants volunteering, 52 consistent high performers and 57 consistent low performers were selected. Information was collected on their study habits, metacognitive strategies, cognitive ability, class attendance, and the amount of support services they used with reference to each of four tests taken in the course. Overall, the most powerful predictor was the score on the Scholastic Aptitude Test verbal section (SATV). The second most discriminating variable was the students' own predictions of examination performance, a measure of metacognition. Another obvious discriminating factor was class attendance. Implications of considering the SATV as a measure of reading comprehension or as a measure of ability are discussed. (Contains 3 tables and 24 references.) (SLD)

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Making the Grade in Undergraduate Biology Courses: Factors that Distinguish High and Low Achievers

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Making the Grade in Undergraduate Biology Courses: Factors that Distinguish High and Low Achievers

Purpose of the Study

The overall purpose of this study was to determine the factors that influence college students' performances in introductory biology courses. More specifically, since many students enroll and are unsuccessful in introductory biology courses, we were interested in examining a broad range of student characteristics that seemed to distinguish high from low performers. These factors included cognitive, metacognitive, and studying behaviors.

Perspectives

Although there have been recent studies examining the processes and strategies necessary to understand scientific text (Mayer, 1985), few studies have been student-centered. These studies have focused on instructional strategies (Abraham, 1989; White & Tisher, 1986), specific text-centered strategies such as concept mapping (Novak & Gowin, 1984), and critical thinking (Crow, 1989; Moll & Allen, 1982). Thus when we undertook this study, one of our goals was to focus more on the student by examining a wide variety of student characteristics including how they approached studying. Through an examination of the extreme cases, those who scored consistently high and those who scored consistently low, our more long-term goal is to build a model of the factors necessary to do well in undergraduate biology courses.

Research in the area of studying and learning suggests that when students study, they need to consider several factors -- the text, the task, their own learning styles, and the strategies used (Jenkins, 1979). At the core of these factors is the level of cognitive tasks that students are asked to undertake (Simpson & Nist 1992). Unless students understand what it is the professor expects from them, both in terms of test format and level of thinking required, they will choose inappropriate studying methods.

In addition, there are also certain generic strategies that are important to student success. Perhaps most crucial is the ability to monitor learning, or metacognition. Students must be able to distinguish what they know from what they do not know, with a degree of accuracy, if they are to be successful on tests and in college coursework (Pressley, Synder, Levin, Murry & Ghatala, 1987).

But there are also domain-specific strategies that are needed in order to study scientific material effectively. Science also requires approaches different from other disciplines, which often leads to students' difficulties in adjusting their studying behaviors to the demands of science courses. Larkin and Reif (1989) suggest that learning science is basically a problem solving task and that in order be successful, students must be able to construct scientific rather than naive representations.

Another difficulty that students encounter in the sciences,

especially in biology, is simply coping with the amount of new terminology and attempting to understand the linkage that exists among terms. In addition, college biology texts and lectures are dense (Ryan, 1989). This often hinders students' attempts at constructing scientific representation. Still, many naive learners view learning scientific information as a memorization of facts task without understanding the importance of conceptualization, synthesis, and determining how the terms help form the "big picture." Yet little has been undertaken at the college level to assist students with knowing what to do in order to perform well in required science classes.

Methods

Participants. All participants were drawn from two large-lecture sections of BIO 103, the first of a mandatory two course lab science requirement. During the first week of class, students were informed of the nature of the research and were offered 16 extra points added on to their total course points if they participated. Of the 644 students enrolled, 612 students volunteered to participate. Although participants were drawn from two different sections, the same professor taught both classes, and the content and exams were identical.

Because of the voluminous amount of data collected, we decided to begin by examining only the extremes of the grading distribution -- consistently high performers (a grade of A or B on each of the four exams) and the consistently low performers (a grade of D or F on each of the four exams). These two groups were selected in order to determine the more pervasive factors that seemed to distinguish high from low performers. There were 52 participants who scored consistently high (X = 87.2 across all four exams), and 57 participants who scored consistently low (X = 56.3 across all four exams). There were 23 females in the high group and 27 females in the low group. The majority of the participants in both groups were freshmen and sophomores.

Data Collection. This study was undertaken at the request of a biology professor on campus who was frustrated with student performance and what seemingly was a lack of self-regulated active learning in his introductory biology courses. Our goal, then was to gather as much information about the students enrolled in this course (BIO 103).

Several different types and sources of data collection were used in order to obtain a broad-based profile of students cognitive, metacognitive, and studying behaviors. First, all students initially completed the <u>Approaches to Studying Questionnaire</u> (Gibbs, 1991) to determine how they approached studying specifically for this biology course. Second, throughout the 10-week term, we continued to collect a wide variety of information via a series of four surveys. For each of four exams, all participants completed a studying survey on which they responded to open-ended questions about how they prepared for the exam, how long they studied, a variety of metacognitive data, and other factors relating to test preparation. Each survey was turned in immediately before each of the four exams.

The purpose of the questions asked on the surveys was to tap both cognitive and metacognitive factors that might influence test performance.

Third, we kept records of class attendance and the amount and type of support services students utilized as they prepared for the tests. These support services included strategy intervention seminars, review sessions, and computer assisted test practice. Additional data on background in science and SAT scores were also collected. Thus at the end of the term, we had an collected an enormous amount of data about students' characteristics, how they were studying for exams, and how or if their studying behaviors changed. This portion of the study focused on a quantifiable set of student characteristic data.

Results

Descriptive data, in the form of means and standard deviations for each of the variables, are located in Table 1. These data provide some initial clues to the factors that distinguish high from low performers.

Insert Table 1 about here

The remainder of the analysis involved three steps. First, we were interested in determining if there were overall differences in student characteristics between the high and low performers for each of the four course exams. Results of the Wilks' statistic used to answer this question can be found in Table 2. These analyses indicated that there were overall differences, thus indicating the need for additional analyses to determine the nature of the differences.

Insert Table 2 about here

Stepwise discriminate analysis was then used to determine the factors that discriminated between high and low performance as well as the degree to which factors and combination of factors contributed to performance on each of the four exams. The results of these analyses can be found in Table 3.

Insert Table 3 about here

These results indicated that the degree to which a particular group of variables discriminated between the two groups was highly consistent for the four exams. Although there was slight variation, the key discriminating variables were SATV, students' ability to accurately predict their exam scores, and the number of times students missed class. Other variables with lesser discriminating power included the SATQ score, the score on the strategic scale of the Approaches to Studying Questionnaire, and, to a lesser degree, the support variables. This finding is important because it indicates that there appears to be a

consistent combination of factors that high performers possess or engage in, but low performers do not.

Discussion

Overall, students' SATV score was the most powerful discriminator. For tests 1, 2, and 3, SATV was the most significant variable. For test 4, SATV was second but was still highly significant. This is not a particularly surprising finding since the SATV, for the most part, taps students' ability to read, indicate understanding through answering a series of predominately higher-level comprehension questions, think critically, and respond to often difficult vocabulary items. Thus, it might be argued that the SATV and general reading comprehension tests tap the same kinds of processes. Dreher and Singer (1985) found that when a group of incoming freshmen were given a reading comprehension test (STEP) and their score was substituted at the end of the year into the college prediction equation for the SATV, the amount of variance accounted for in first year GPA was almost identical (STEP accounted for about 1% less of the variance than SATV). Royer and his colleagues (Royer, Abranovic, & Sinatra, 1987; Royer, Marchant, Sinatra, & Lovejoy, 1990) have had similar findings.

On the positive side, if one views the SATV as more a test of reading comprehension than a test of ability, interventions may be designed to improve students' overall reading comprehension in biology. There has been a considerable amount written which outlines the active strategies necessary to be successful in biology courses. These strategies include critical reading and thinking skills (Moll & Allen, 1982), formulating questions (Crow, 1989), vocabulary interaction (Ryan, 1989), and interpreting diagrams (Ryan, 1989). Students can be taught these skills and strategies, although it is neither a short-lived or simplistic solution.

However, these results can be viewed as disturbing, particularly if one views the SATV more as a measure of ability or aptitude (as the name states). Measures of ability are more stable and difficult to impact. And there are data which indicate that students who attend SAT preparation courses improve their scores only slightly or not at all (Becker, 1990). The data from the current study suggest that other factors or combination of factors may not make up for a lower SATV score, at least without intervention. That is, students entering introductory biology courses who have lower SATV scores may be doomed to struggle. As an aside, another interesting note is that we had difficulty finding studies that even broached the idea of measures of ability and success in science. When the ability was researched it tended to focus on areas such as problem solving ability (Larkin & Reif, 1979) or on Piaget's theory of intellectual development (Novak, 1978). Rather, the more prevalent attitude by science educators appears to the that all students can learn science (Cherif, 1994)

The second most discriminating variable was students' exam predictions, which is a measure of metacognition. In the area of science, much of the metacognitive research has been examined in

conjunction with conceptual change (Duit, 1991). Students who can separate what they understand from what they do not comprehend better and stand of better chance of being able to change incorrect scientific perceptions. But there has been a considerable amount of general reading and studying research that has shown a strong relation between metacognition and test performance (Nist, Simpson, Olejnik, & Mealey, 1991; Pressley, et al., 1987).

In addition, Nist and Simpson (1990) found that students who are higher performers also tend to be better predictors. The results of the present study concurred with this finding. Results indicated that metacognition as measured by students' ability to predict their test grades was consistently a discriminating factor. High performers predicted they would indeed make high scores. But low performers consistently also predicted that they would make higher grades than they actually did. In fact, often low performers predicted grades that were two grades higher than what they actually received. Additionally, the problem of inaccurately predicting exams scores did not improve from the first to the last exam as has been shown in other research (Nist & Simpson, 1990).

Although some previous research indicates that even college students have poorly developed metacognitive skills (Baker & Brown, 1984), with training, students can be taught to monitor their learning, thus improving their ability to predict test scores. But as Wandersee, Mintzes, and Novak (1994) caution, training in metacognition skills is neither a quick fix nor a way to make learning easier.

The other more obvious factor that discriminated between high and low performers was class attendance. Low performers missed almost three times as many classes as did high performers. This finding agrees with other studies which show that there is a moderate to strong relation between attending class and performance in the class (Jenne, 1973; Levine, 1992; Nist & Simpson, 1992). But, the problem here is a "chicken and egg" one. Can poor performance be explained by class attendance or do poorer students just not attend class because they do poorly and rationalize that they will just not do any better even they attend? Thus the problem becomes cyclical.

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Table 1
Means and (Standard Deviations) for each Variable by Group

	Low	High
Test 1	52.09 (7.94)	85.25 (5.89)
Test 2	59.28 (7.10)	87.89 (5.55)
Test 3	58.25 (7.04)	90.42 (4.71)
Test 4	54.50 (10.17)	87.00 (5.61)
SATV	434.39 (68.44)	552.88 (76.44)
SATQ	465.60 (81.18)	586.88 (89.28)
Absences	1.89 (2.06)	.46 (1.00)
Inter 1	.17 (.38)	.05 (.23)
Inter 2	.07 (.27)	.04 (.19)
Inter 3	.17 (.37)	.04 (.19)
Inter 4	.06 (.23)	.05 (.23)
Study 1	.13 (.34)	.14 (.35)
Study 2	.11 (.31)	.13 (.33)
Study 3	.17 (.38)	.14 (.35)
Study 4	.07 (.27)	.03 (.19)
Pred 1	2.49 (.57)	3.37 (.67)
Pred 2	2.27 (.75)	3.30 (.72)
Pred 3	2.10 (.75)	3.29 (.73)
Pred 4	1.96 (.74)	3.16 (.65)
Hours St 1	5.40 (3.95)	5.00 (3.85)
Hours St 2	5.59 (3.95)	4.67 (3.45)
Hours St 3	4.97 (2.96)	4.15 (2.60)
Hours St 4	4.75 (3.27)	3.93 (3.30)
ASQ 1 (Ach)	15.98 (3.60)	16.96 (2.65)
ASQ 2 (Repro)	17.44 (3.70)	14.60 (4.17)
ASQ 3 (Mng)	13.42 (3.42)	15.79 (3.54)
Sci Courses	1.50 (1.64)	1.74 (1.37)
Comp Prac 2	.36 (.48)	.53 (.50)
Comp Prac 3	.31 (.47)	.76 (1.35)
Comp Prac 4	.44 (.50)	.59 (.49)
Meta + 1	1.25 (1.12)	2.29 (.94)
Meta + 2	1.12 (1.05)	2.11 (1.14)
Meta + 3	1.00 (.99)	2.04 (1.17)
Meta + 4	.83 (1.03)	1.49 (1.24)
Meta - 1	1.00 (.77)	.50 (.71)
Meta - 2	.90 (.75)	.48 (.72)
Meta - 3	.83 (.75)	.57 (.68)
Meta - 4	1.18 (.85)	.81 (.70)

Table 2
Wilks' Lambda Statistic for Tests 1 - 4.

Test	F	p
1	8.68	.0001
2	5.45	.0001
3	7.21	.0001
4	9.26	.0001

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Table 3
Stepwise Discriminate Analysis Indicating Factors that Discriminate Between High and Low Performers.

Test	Variable (rank)	Partial R^2	F	p
1	SATV (1)	.418	49.67	.0001
	PTG (2)	.270	25.17	.0001
	IP (3)	.079	5.78	.0189
	AB (3)	.094	6.86	.0109
	SATQ (4)	.037	2.55	.1147
	ASQ3 (4)	.034	2.28	.1357
2	SATV (1)	.424	49.43	.0001
	PTG (2)	.104	7.70	.0072
	AB (3)	.086	6.11	.0160
	SATQ (3)	.070	4.84	.0314
	ASQ3 (3)	.067	4.53	.0371
3	SATV (1)	.443	49.48	.0001
	PTG (2)	.207	15.99	.0002
	IP (3)	.068	4.41	.0399
	AB (3)	.058	3.64	.0610
	ASQ3 (3)	.059	3.69	.0594
	SATQ (3)	.058	3.51	.0661
4	PTG (1)	.438	48.43	.0001
	SATV (2)	.291	25.10	.0001
	AB (3)	.102	6.81	.0114
	SSP (3)	.092	6.03	.0170
	SATQ (4)	.047	2.91	.0933
	ASQ3 (4)	.057	3.47	.0675

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